3 SHEETS

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Sheet 3

Fig 5

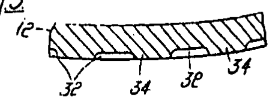


Fig 6

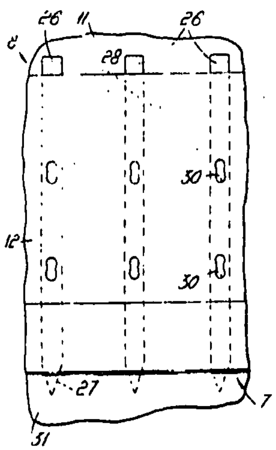


Fig 7

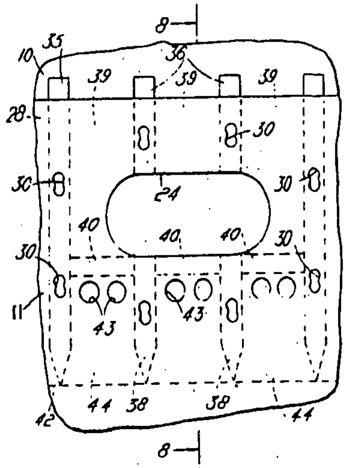


Fig 8

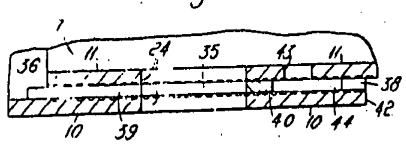
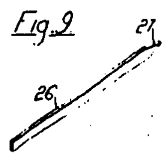


Fig 9



PATENT SPECIFICATION

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(19)

(54) COMBUSTION LINER

(71) We, GENERAL MOTORS CORPORATION, a Company incorporated under the laws of the State of Delaware, in the United States of America, of Grand Boulevard, in the City of Detroit, State of Michigan, in the United States of America (Assignees of ALBERT JAN VERDOUW) do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates primarily to liners for high heat release combustion chambers such as are used, for example, in gas turbine engines. It is particularly directed to provision of a combustion liner suitable for operation at very high temperatures, with the ratio of fuel to combustion air approaching stoichiometric.

The scope of the invention is defined by the appended claims; how the invention may be performed is particularly described below with reference to a preferred embodiment of the invention shown in the accompanying drawings, in which:

Figure 1 is a front elevation view of an annular combustion liner with the combustion chamber walls shown fragmentarily.

Figure 2 is a sectional view of the liner taken on a plane substantially containing its axis, as indicated by the line 2–2 in Figure 1.

Figure 3 is a partial cross sectional view taken on the plane indicated by the line 3–3 in Figure 2.

Figure 4 is an enlarged fragmentary view showing the roughened surface of the wall of the combustion liner cooling air inlet.

Figure 5 is a still further enlarged section of the same, taken on the line indicated by the line 5–5 in Figure 4.

Figure 6 is a fragmentary plan view illustrating a portion of the overlap between the second and third sections of the liner wall.

Figure 7 is a fragmentary plan view illustrating a portion of the overlap between the first and second sections of the liner wall.

Figure 8 is an enlarged fragmentary sectional view taken on the plane indicated by the line 8–8 in Figure 7.

Figure 9 is a view of a coupling strip which connects the liner sections.

Referring first to Figures 1, 2, and 3, the invention is embodied in an annular combustion liner 2 which is disposed between an outer combustion chamber casing 3 and an inner combustion chamber casing 4. These are made of suitable high temperature resistant metal, primarily sheet metal, and define a space to which air under pressure is supplied by a compressor or other suitable apparatus, and from which it flows into the combustion liner 2 within which combustion takes place and from which the combustion products are exhausted to a turbine or other point of use.

The combustion liner 2 includes an annular front wall 6, a radially inner wall 7, and an outer wall 8. While there are detail differences between the inner and outer walls, they are the same in principle and, therefore, the sections of the two walls will be identified by the same reference numerals for brevity of exposition. Each of the walls 7 and 8 includes a front section 10, a middle section 11, and a rear section 12. The front sections 10 extend forwardly beyond the front wall 6, and the rear sections 12 converge to define between them an outlet 14 for the combustion products. The outlet end of the combustion liner may be suitably supported on a turbine nozzle (not shown)

The front wall 6 is fixed to the front sections 10 by circumferentially extending zigzag strips 15 which provide annular film cooling air inlets at the forward end of the combustion liner. A number of fuel nozzle sockets 16 are distributed around the front wall. Specifically, there are sixteen sockets. Fuel spray nozzles (not illustrated) enter these sockets. Four supports 18 projecting from the forward part of the liner wall (Figure 1) service to center and support the liner. The front wall 6 also includes air inlets to provide air to scour the inner surface of the wall 6, which need not be described here as they are immaterial to the invention.

Baffles 19 supported by rings 20 from the walls 7 and 8 are provided to control the flow of air into the liner. Combustion air flows into the liner through air inlet grommets 22, there being thirty-two such grommets in each wall 7 and 8 in the specific liner illustrated. Small baffles 23 extending over the rear part of the entrance to grommets 22 aid in controlling air flow into the liner. Downstream of

grommets 22 there are disposed sixteen additional combustion air inlet holes 24 in each of inner wall 7 and outer wall 8. Before proceeding to a description of the structure associated with these inlet holes, however, it is best to consider the structure involved in the area of overlap between the middle wall section 11 and the rear wall section 12.

Referring to Figure 2 and particularly Figure 6, which last figure shows the joint between the middle and rear sections of the outer liner wall 8 there is a very substantial overlap between the wall sections 11 and 12. Throughout this overlap area the wall sections are maintained uniformly spaced from each other and are physically coupled to each other through coupling strips 26 (see also Figure 9) which are thin narrow toothpick-like elements of sheet metal of rectangular outline except that the end 27 which is disposed downstream in the combustion liner is pointed. In the specific case, these are three hundredths of an inch thick. The coupling strips 26 are bonded to the wall sections which they thus mechanically interconnect. The cooling air inlets 28 between sections 11 and 12 are defined by the gap between these two liner sections and between adjacent coupling strips 26. In the particular example illustrated, these are one hundred and twenty such coupling strips in the outer wall and eighty in the inner wall, which is of smaller diameter, so that the distance between the strips in both cases is about one-half inch. Each coupling strip 26 is brazed to the wall section 11 and, when the liner is assembled lies under two or more holes 30 in the section 12. In the assembly of the combustion liner, the shaped holes 30 are filled with weld or braze metal to mechanically lock the sections 11 and 12 of the liner together through the strips 26. Since strips 26 are numerous and closely spaced, they preserve the spacing of the two liner sections and, therefore, the dimension radially of the combustion liner of the air inlets 28.

Figures 2 and 6 also illustrate an outer wall layer 31 which forms part of the structure by which the combustion liner is supported in the engine. The coupling strips 26 are approximately 0.03 inch thick so that the air inlets 28 are about this width. The tapered or pointed end 27 of the coupling strips 26 causes the air passing through the inlets 28 to spread out uniformly over the inner surface of the combustion liner wall downstream of the coupling strips.

For improved utilization of the cooling air in accordance with the invention, the portions of the wall sections 11 and 12 which are in mutually overlapping relation have their confronting faces specially roughened so as to create turbulence in the air flow through the cooling air inlets 28 and improve heat transfer to the walls, particularly to the wall 11 which is on the combustion side or inside of the liner. In the preferred embodiment of the invention, the metal of the walls 11 and 12 is approximately 0.04 inch thick. To provide the rough surface as illustrated in Figures 4 and 5, the surface is chemically etched to a depth of approximately 0.007 inch to provide a grid of intersecting grooves 32 which have between them projecting generally rectangular bosses 34 about 0.02 to 0.03 inch in width where no etching takes place. These chemically etched surfaces extend from the forward edge of section 12 to the rearward edge of section 11, thus providing the roughened surface on both boundaries of the cooling air inlets.

It has been found that more effective cooling can be obtained in this respect than with a prior structure with normally smooth sheet metal surfaces on the walls for the cooling air inlets and in which the air flow was about fifty per cent greater, leading to much greater dilution of the combustion products. The air which flows from the rear end of the inlets 28 will flow over the inner surface of the rear wall section 12 to achieve some measure of film cooling at this point.

The arrangement of the cooling air inlets between the front wall section 10 and the middle wall section 11 is based upon the same principles as between the middle and rear wall sections. However, there are substantial modifications or additions because of the presence of the large air inlets 24 which lie approximately midway of the overlap between the front and middle wall sections in both the inner and outer walls. In the particular example shown, there are sixteen holes 24 through each wall. Four coupling strips 35 which may be identical to the coupling strips 26 except of somewhat different length, join the wall sections 10 and 11 between each two adjacent combustion air holes 24 in the inner wall; and four such coupling strips 35 lie between each two adjacent air holes 24 in the outer wall 8 in which, of course, the holes 24 are spaced farther apart.

To space and couple the wall sections in the region of the holes 24, front strips 36 (Figures 7 and 8) are provided upstream of openings 24 and rear strips 38 rearwardly of openings 24. It will be seen the strips 36 and 38 taken together are essentially the same as strips 35 except that the gap between them leaves the air entrance 24 clear. The wall section 11 has two braze metal holes 30 of figure eight configuration over each strip 35 and one over each strip 36 or 38. Strips 35, 36 and 38 are welded to the forward wall section 10. Holes 24 extend through both the wall sections 10 and 11 are aligned with each other at the time the liner is assembled.

Since the air flow through the holes 24 would intercept or block the flow through the passages 39 between the coupling strips which are intersected by holes 24, the air flowing from the forward part of these inlets is allowed to

flow into the combustion liner through the holes 24. This leaves a need for cooling of the overlapping portions of wall sections 10 and 11 in the areas downstream of the holes 24. It is important to provide cooling here and to avoid recirculation of hot combustion products between the wall sections. To accomplish this, blocking strips 40 welded to the wall section 10 extend from the coupling strip 35 to the adjacent rear strip 38 and between the rear strips 38 so that the air inlets 39 are blocked off to the rear of combustion air hole 24. To cool the portion of wall section 10 between each hole 24 and the rear edge 42 of wall section 10, two small auxiliary cooling air holes 43 are punched through the rear or outer wall section 11 immediately downstream of blocking strips 40.

Air entering through holes 43 flows through passages 44 defined between the wall sections 10 and 11 and between the rear strips 38 and between these strips and the adjacent strips 35. In the portions of the inlet remote from the combustion air holes 24, the flow is as previously described through inlets 28 between strips 26.

It may not be obvious why the outer wall (away from the flame) of the air inlets is roughened, since the inner wall is the one requiring most of the cooling. However, roughening both walls increases turbulence and thus benefits heat transfer from the hot wall of the cooling air inlet. If only the inner wall is roughened, the cooling air flow may follow the outer wall to the detriment of cooling of the inner wall, and more air may be required for the same cooling effect.

It should be apparent from the foregoing to those skilled in the art that the structure described is a combustion liner of very practical structure, readily assembled, and that it particularly provides for cooling of the walls with a minimum of air flow and primarily by cooling of the walls by convection rather than by pure film cooling, since the overlapping portions of the combustion liner wall are much greater in extent than the portions between the overlaps.

WHAT WE CLAIM IS:–

1. A combustion liner for use in high-temperature combustion apparatus working at a high fuel to air ratio approaching stoichiometric comprising, in combination, first and second wall portions overlapping and mutually spaced and defining between them a cooling air inlet into the liner, the said portions thus providing an inner wall bounding the combustion side of the inlet and an outer wall bounding the other side of the inlet, the air flowing through the inlet being employed to cool the said wall portions; the surfaces of the inner and outer walls defining the inlet being roughened to increase the heat transfer per unit of air flow from the walls to the air entering the inlet.

2. A combustion liner as claimed in Claim 1 in which the said wall portions are chemically etched to provide the said roughened surfaces.

3. A combustion liner as claimed in Claim 2 in which a grid of intersecting grooves is etched in the said roughened surfaces.

4. A combustion liner as claimed in any previous Claim in which the said surfaces of the said wall portions bear a two-dimensional array of small bosses.

5. A combustion liner as claimed in Claim 1 including coupling strips disposed between and bonded to the said wall portions mechanically connecting the wall portions and establishing the width of the cooling air inlet.

6. A combustion liner for a gas turbine engine combustion chamber, the liner being of a type dividing an air space, from which combustion air is supplied, from a combustion space in which air and combustion products flow longitudinally of the liner to a combustion products outlet; the liner including a wall dividing the air space from the combustion space: the wall comprising, in combination, a forward wall section and a rearward wall section; the rearward wall section including a portion overlapping and outwardly spaced from the forward wall section, the forward wall section including a portion overlapping and inwardly spaced from the rearward wall section, the said portions defining between them an inlet from the air space to the combustion space for cooling air to flow into the liner and along the rearward wall section for film cooling of the rearward wall section; the said wall portions defining combustion air holes extending through the said wall portions for flow transverse to the cooling air flow; barrier means blocking the cooling air inlet downstream of the combustion air holes; auxiliary cooling air inlets defined by and extending through the rearward wall section into the cooling air inlet immediately downstream of the barrier means; and the wall surfaces defining the cooling air inlet having a rough texture to promote turbulent flow in the cooling air inlet and heat transfer from the liner wall to the cooling air.

7. A combustion liner as claimed in Claim 6 including coupling strips disposed between and bonded to the said wall portions mechanically connecting the wall portions and establishing the width of the cooling air inlet.

8. A combustion liner as claimed in Claim 7 in which some of said coupling strips are in two parts, respectively forward of the combustion air holes and rearward of the combustion air holes.

9. A combustion liner for a gas turbine engine combustion chamber, substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

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Fig.1.

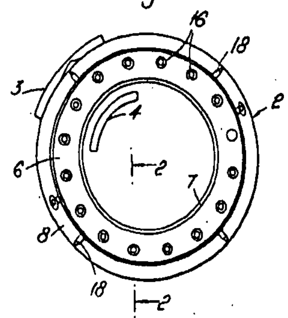

Fig.3.

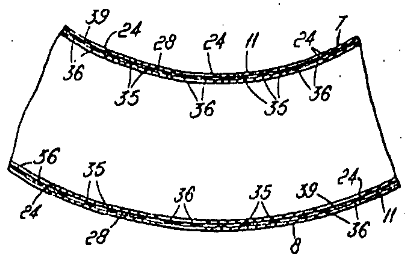

Fig.4.

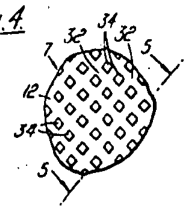

Fig.2.